PATENT ABSTRACTS OF JAPAN

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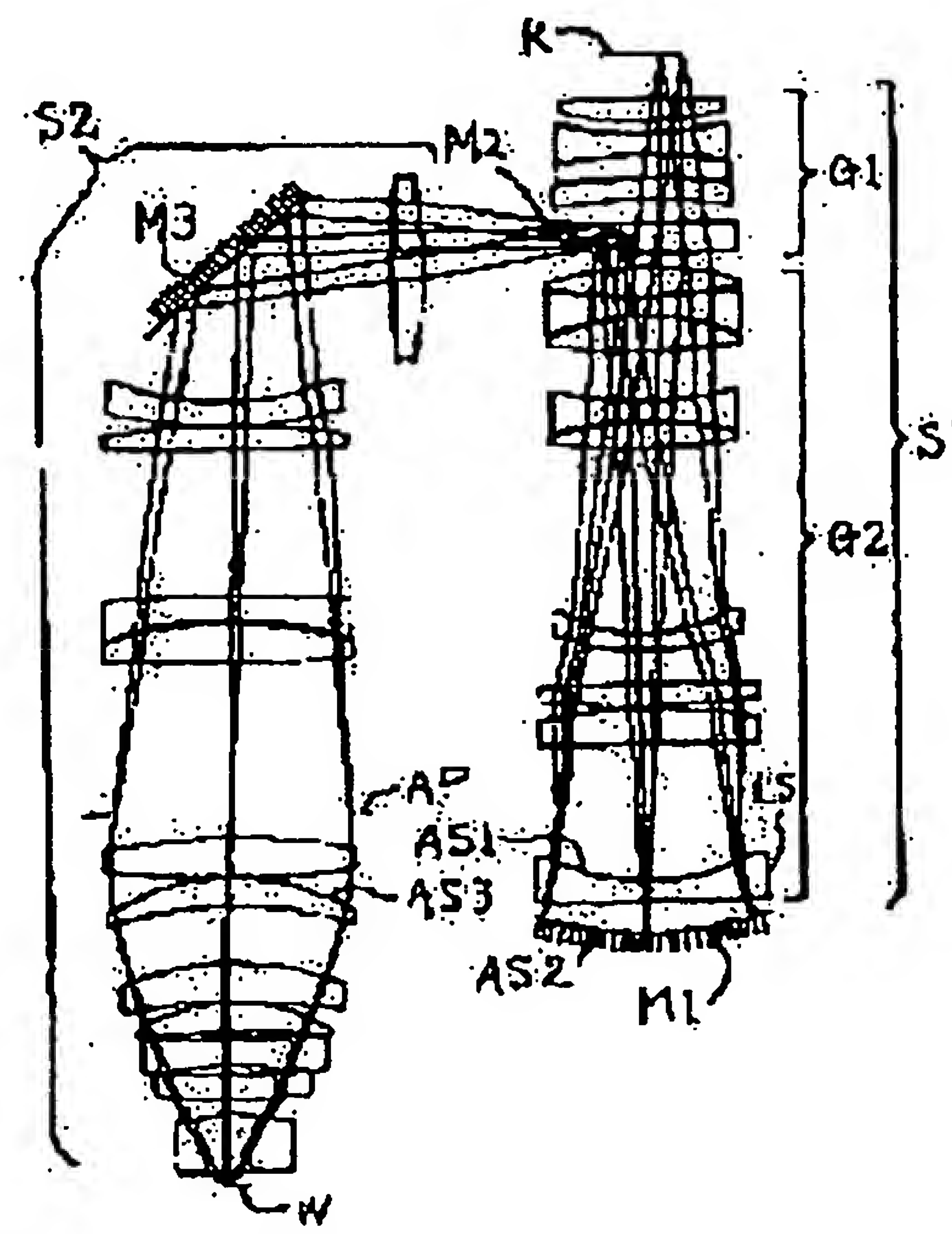
(54) REFLECTIVE/REFRACTIVE OPTICAL SYSTEM

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a reflective/refractive optical system having a large numerical aperture in the ultraviolet wavelength region, a practical size as a whole, and a resolving power of quarter micron unit, and miniaturizing the respective component members of the optical system.
SOLUTION: This optical system includes a first image forming optical system S1 composed of a refractive member, a concave mirror M1 and a second image forming optical system S2 composed of a refractive member and the pattern of a semiconductor element is projected on a substrate. In this case, between the refractive member composing the first image forming optical system S1 and the refractive member composing the first image forming optical system S2, at least one refractive member is made to have an aspherical surface.



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CLAIMS

[Claim(s)]
[Claim 1] It is the cata-dioptric system characterized by for at least one refraction member to have the aspheric surface among the refraction members which constitute the refraction member which constitutes said 1st image formation optical system, and said 2nd image-formation optical system in the cata-dioptric system which projects the pattern of a semiconductor device on the order in which a beam of light advances to up to a substrate including the 1st image-formation optical system constituted by the refraction member, a concave mirror, and the 2nd image-formation optical system constituted by the refraction member.
[Claim 2] The beam of light which said 1st image formation optical system consists of the 1st lens group which a beam of light passes only at once, and the 2nd lens group to which a beam of light goes and comes back, and the lens nearest to a concave mirror of this 2nd lens group is a negative lens, and injected said 2nd lens group is cata-dioptric system according to claim 1 characterized by carrying out image formation of the pattern of said semiconductor device once before carrying out incidence to said 2nd image formation optical system.
[Claim 3] Cata-dioptric system according to claim 1 or 2 characterized by having arranged the optical-path deviation member between said 1st image formation optical system and said 2nd image formation optical system.
[Claim 4] The refraction member which constitutes the refraction member which constitutes said 1st image formation optical system, and said 2nd image formation optical system is cata-dioptric system according to claim 1 to 3 characterized by being constituted by a quartz and fluorite, or any its one ** material.
[Claim 5] Said concave mirror is cata-dioptric system according to claim 1 to 4 characterized by being an aspheric surface configuration.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the optical system used with the projection aligner used in casi a semiconductor device or a liquid crystal display component is manufactured at a photolithography process. It is related with the cata-dioptric system which has the resolution of a quarter micron unit in an ultraviolet-rays wavelength region by using a reflecting mirror as an element of optical system especially.
[0002]
[Description of the Prior Art] In the photography process for manufacturing a semiconductor device etc., the projection aligner exposed on substrates (a wafer is called collectively hereafter), such as a wafer with which the photo mask or reticle (a reticle is called collectively hereafter) on which the pattern of a semiconductor device was drawn was applied to the photoresist etc. through projection optics, or a glass plate, is used. The resolution required of the projection optics currently used for the projection aligner is increasing increasingly a: degrees of integration, such as a semiconductor device, improve. In order to satisfy this demand, numerical aperture (NA) of projection optics needed to be enlarged short [wavelength / of the illumination light]. In orde to fill these demands, the various techniques which constitute projection optics from so-called cata-dioptric system which combined a reflective system and refractive media are proposed.
[0003] For example, the cata-dioptric system using the exposure field containing the beam of light on an optica axis is indicated by JP,63-163319,A and JP,5-25170,B. Moreover, not using an optical-axis top, there is optical system indicated by JP,7-111512,B and USP-4,779,966 No. as optical system using a zona-orbicularis-like exposure field.
[0004]
[Problem(s) to be Solved by the Invention] It is necessary to use the beam splitter which had a transparency reflector for optical-path division in the cata-dioptric system using the exposure field containing the beam of light on the above-mentioned optical axis. In such optical system, it is easy to generate the stray light leading to a flare or lighting nonuniformity in the internal reflection by the reflected light from a wafer side, the internal reflection in the refracting interface of the optical-system after a beam splitter, the transparency reflector of a beam splitter, etc. Moreover, when a numerical aperture is enlarged, a large-sized beam splitter is needed, and huge-ization of the exposure time by the quantity of light loss causes the fall of the throughput in a semi-conductor production process. Manufacturing a large-sized polarization beam splitter's having un-arranged [that it is very difficult and the heterogeneity of the transparency reflective film, an include-angle property, absorption, a phase change, etc. degrade an image formation property], although adoption of a polarization beam splitter was needed in order to prevent a quantity of light loss as furthermore indicated by JP,6-300973,A etc.
[0005] On the other hand, in the cata-dioptric system indicated by the USP-4,779,966 No. using a zona-orbicularis-like exposure field, catoptric system is adopted as a contraction [side / wafer] side rather than the middle image. However, since NA is large compared with a reticle side side, optical-path division can be difficult, and cannot enlarge NA of optical system, and a contraction side cannot have sufficient resolution. Moreover, enlargement of a concave mirror is not avoided, either.
[0006] In the cata-dioptric system similarly indicated by JP,7-111512,B using a zona-orbicularis-like exposure field, the 1st image formation optical system containing the concave mirror for forming a middle image consist: of optical system of a perfect symmetry mold, and the middle image is the actual size image of a reticle side.

Although aberration generating of the 1st image formation optical system is made to mitigate by this, the 2nd image formation optical system will take charge of the scale factor of the whole system alone, and the burden concerning the 2nd image formation optical system becomes heavy. If big NA is required especially of optical system, enlargement of the 2nd image formation optical system and complication will not be avoided.
[0007] In view of this point, this invention attains big numerical aperture in an ultraviolet-rays wavelength region, the whole optical system is practical magnitude, and it has the resolution of a quarter micron unit, and aims at offering the cata-dioptric system which miniaturized each configuration member of optical system.
[0008]
[Means for Solving the Problem] The 1st image formation optical system S1 constituted from this invention by the refraction member by the order in which a beam of light advances in order to attain the above-mentioned purpose, In the cata-dioptric system which projects the pattern of a semiconductor device to up to a substrate including a concave mirror M1 and the 2nd image formation optical system S2 constituted by the refraction member At least one refraction member offers the cata-dioptric system characterized by having the aspheric surface among the refraction members which constitute the refraction member which constitutes said 1st image formation optical system, and said 2nd image formation optical system.
[0009]
[Embodiment of the Invention] As mentioned above, by adopting an aspheric surface configuration as a refraction member in this invention, it becomes possible to enlarge NA of mitigating generating of high order aberration, and optical system, and enlargement of optical system and complication can be prevented. This can bend now the flux of light around a lens side ideally by shifting a refracting interface from the spherical surface It is because it comes to be able to perform high order aberration amendment by it, without extending the whole flux of light.
[0010] If the refracting interface of an aspheric surface configuration is especially introduced into the 1st image formation optical system S1, enlargement of the 1st image formation optical system S1 can be prevented, and if the refracting interface of an aspheric surface configuration is introduced into the 2nd image formation optical system S2, enlargement of the 2nd image formation optical system S2 can be prevented. Moreover, it consists of the 1st lens group G1 in which a beam of light passes the 1st image formation optical system S1 only at once at this invention, and the 2nd lens group G2 to which a beam of light goes and comes back, and the lens nearest to a concave mirror M1 of the 2nd lens group G2 is negative lens LS, and before carrying out incidence of the beam of light which injected the 2nd lens group G2 to the 2nd image formation optical system S2, it is desirable [the beam of light] to carry out image formation of the pattern of a semiconductor device once. If it is especially made arrangement of such optical system, the miniaturization of each configuration member can be attained. The configuration of carrying out image formation of the pattern of a semiconductor device once before the beam of light which has arranged the lens nearest to a concave mirror M1 of the 2nd lens group G2 in the order in which a beam of light advances with negative lens LS, a concave mirror M1, and the 2nd image formation optical system S2, and injected the 2nd lens group G2 in it moreover carries out incidence to the 2nd image formation optical system S2 is very effective in reduction of axial overtone aberration.
[0011] In the case of the above optical system of a configuration, it is desirable to consist of a refraction member in which the 2nd lens group G2 has at least two different negative refractive power, and a refraction member with at least two different forward refractive power further. The lens with negative refractive power is greatly effective in amendment of comatic aberration, spherical aberration, a curvature of field, etc., and without optical system becoming large, since it has big NA and a big, big exposure field, the lens with forward refractive power is effective. Furthermore, in order to compensate the aberration of the 2nd image formation optical system S2 and to make light the burden of aberration amendment of the 2nd image formation optical system S2, it is desirable to have two lenses at a time respectively at least.
[0012] And as for the 1st lens group G1, it is still more desirable to consist of refraction members with at least three different refractive power. Spec. also with severe amendment of distortion aberration and amendment of a curvature of field is demanded as optical system is recently asked for resolution. Although the adjustment at the time of manufacture is needed for this achievement, the lens for adjustment has an effective lens near the reticle side. However, since the 2nd lens group G2 of the optical system of this invention is both-way combination optical system, it can be said that it is unsuitable as a lens for adjustment. Therefore, the adjustment at the time of manufacture of distortion aberration or a curvature of field is attained by constituting from a lens which has

at least three different refractive power in the 1st lens group G1. Moreover, by making the 1st lens group G1 t above-mentioned configuration, it becomes possible to enlarge working distance near the Rth page of a reticl and exposure of step - and - scanning method can be realized.

[0013] Moreover, the 2nd image formation optical system S2 mainly amends spherical aberration and comati aberration, and plays an important role for optical system to have big NA. It is desirable to arrange the optical path deviation member M3 in this invention between the 1st image formation optical system S1 and the 2nd image formation optical system S2. This is because it becomes possible to bend the whole optical system and the miniaturization of the whole optical system can be attained by arranging optical-path deviation members, such as a mirror.

[0014] Moreover, in order that wavelength may use the short wavelength exceeding 300nm as the light sourc for exposure in this invention, especially, the quantity of light transparency property in this field is good, and economical, and it is desirable to use the good quartz or fluorite of workability. Moreover, a concave mirror M may be formed in an aspheric surface configuration in this invention. A concave mirror M1 can enlarge forwa refractive power which a concave mirror M1 has without generating of high order aberration as it is an aspher surface configuration, and the chromatic-aberration amendment of it about the wavelength of a broadband is attained at implementation of the miniaturization of optical system, and the formation of large NA, and a pan.

[0015] In addition, a coherence factor (sigma value) can be adjusted by preparing an aperture diaphragm (variable aperture) into the optical path of the 2nd image formation optical system S2. As the one technique o making the depth of focus deep and raising resolving power, the phase shift method which shifts the phase of the predetermined part in the pattern of a reticle from other parts is proposed in JP,62-50811,B. In this invention, since it is possible to adjust a coherence factor (sigma value), there is an advantage which can improve the effectiveness of this phase shift method further.

[0016]

[Example] The numerical example of the cata-dioptric system by this invention is shown below. The cata-dioptric system by each numerical example sequentially from Reticle R side (in order in which a beam of ligh advances) It is constituted by the 1st image formation optical system S1 constituted by the refraction member, concave mirror M1, and the 2nd image formation optical system S2 constituted by the refraction member. Th 1st image formation optical system S1 A beam of light consists of the 1st lens group G1 which passes only at once, and the 2nd lens group G2 to which a beam of light goes and comes back, and the lens nearest to a concave mirror M1 of the 2nd lens group consists of negative lens LS.

[0017] Moreover, image quantity is made by NA=0.6 and aberration amendment is made for each numerical example in the range from 5 to 18.6. In addition, as an exposure field, the range of the above-mentioned imag quantity may be made into the shape of zona orbicularis, and you may make it the rectangle of 6x30 at the pla distant from the optical axis five. r expresses the radius of curvature of a field among each table of the 1st example and the 2nd example, and d expresses spacing of a field. Moreover, a quartz is SiO2 as ** material. Fluorite is CaF2. It has indicated among each table. The refractive index n to 193.0nm of a quartz and fluorite and 1/of the variances nu to **0.1nm are as follows.

[0018]

		n	1／ν
合成石英	:	1．56019	1780
蛍石	:	1．50138	2550

Moreover, the aspheric surface is expressed by the following formulas among each example.

Z=(Y2 / r)/[1+sqrt{1-(1+K) Y2 / r}]+C4 Y4+C6 Y6+C8 Y8+C10Y10+C 12Y12 -- however Z : Distance Y measured in the direction of an optical axis from top-most vertices : Distance K measured in the direction mo nearly perpendicular to an optical axis than top-most vertices : Constant of the cone r : The radius of curvatur C4 of top-most vertices, C6 and C8 ... : The 8th order the 6th order the 4th order in the 1st example of an aspheric surface multiplier [the 1st example] of ... The 1st lens group G1 is constituted from the Rth page of a reticle by a biconvex lens, the biconcave lens, the meniscus lens that turned the convex to the Rth page side o reticle, the meniscus lens which turned the convex to the Rth page side of a reticle, and the plane-parallel plat in order. Moreover, the **** configuration of the 2nd lens group is carried out in order [page / of reticle / Rth at a biconvex lens, a biconcave lens, a biconvex lens, a biconcave lens, a biconvex lens, the meniscus lens tha

turned the concave surface to the Rth page side of a reticle, a biconvex lens, the meniscus lens which turned the convex to the Rth page side of a reticle, and negative meniscus lens LS which turned the concave surface to the Rth page side of the reticle in which the field by the side of Reticle R was formed to the aspheric surface AS 1. Here, the plane-parallel plate in the 1st lens group G1 has processed some lenses into the plane mirror M2 as an optical-path deviation member. And image formation of the image of Reticle R is once carried out near [plane mirror M2] this. Moreover, the concave mirror M1 is formed in the aspheric surface AS 2 in this example.
[0019] The 2nd image formation optical system S2 in order [page / of reticle / Rth] Furthermore, a biconvex lens, The meniscus lens which turned the concave surface to the Rth page side of a reticle, a biconvex lens, the meniscus lens which turned the convex to the Rth page side of a reticle, A biconvex lens, aperture diaphragm AP, a biconvex lens, the meniscus lens that turned the convex to the Rth page side of the reticle in which the field by the side of Reticle R was formed to the aspheric surface AS 3, It consists of the meniscus lens which turned the convex to the Rth page side of a reticle, the meniscus lens which turned the convex to the Rth page side of a reticle, a biconcave lens, a meniscus lens which turned the concave surface to the Rth page side of a reticle, and a meniscus lens which turned the convex to the Rth page side of a reticle. He arranges a plane mirror M3 as an optical-path deviation member between the first lens in the 2nd image formation optical system S2, and the second lens, and is trying for the Rth page of a reticle and the Wth page of a wafer to become parallel by this example here between.
A field number r d ** material 0.000 50.000 R 1 1827. 099 25.000 SiO2 S1 G1 2 - 391.019 13.420 3 - 396.812 25.000 SiO2 4 829.284 1.000 5 459.609 25.000 SiO2 6 745.296 1.000 7 488.042 25.000 SiO2 8 586.033 25.0009 0.000 35.000 SiO2 10 0.000 16.00011361.664 32.175 CaF2 G212 -449.989 1.00013-561.169 20.000 SiO2 14 255.2301.00015223. [249] 39.738 CaF2 16 -756.196 57.48317 -315.859 20.000SiO2 18 299.543 1.00019 260.236 32.584 CaF2 20 - 675.594 211.18821 - 163.356 20.000 SiO2 22 -252.267 38.24123 2280. 139 25.000 SiO2 24 - 1082.014 3.36725 556.937 40.000 SiO2 26 4236. 526 156.69527 - 215.826 25.000 SiO2 LS AS128 -4417.336 33.56129 - 354.342 -33.561 M1 AS230 -4417.336 - 25.000 SiO2 LS 31-215.826 - 156.695AS132 4236.526 - 40.000 SiO2 33556.937 - 3.36734 -1082.014 -25.000 SiO2 35 2280. 139 - 38.24136 252.267-20.000 SiO2 37 - 163.356 -211.18838 - 675.594 -32.584 CaF2 39 260.236 - 1.00040 299.543 - 20.000 SiO2 41-315.859 - 57.48342 -756.196 - 39.738 CaF2 43 223.249-1.00044 255.230 - 20.000 SiO245 -561.169 - 1.00046 - 449.989-32.175 CaF2 47 361.664 - 5.00048 0.000 235.151 M249 687.78230.000 SiO2 S250 - 1403.174 170.00051 0.000-150.026 M352 262.520 - 25.000 SiO2 53474.401 - 1.30454 - 632.711 - 27.786 SiO2 55 5490. 382-168.08156 - 1783.259-25.000 SiO2 57 - 321.439 - 4.40258-357.850 -44.750CaF2 59 3152. 678-173.78760 0.000-28.467 AP61 -566.009 -45.000 CaF2 62 806.950 -1.00063 -212.463 -31.096 CaF2 AS364 - 368.988 -65.19065 -260.201 -44.295SiO2 66 -544.105 -1.00067 -169.071 -31.373 CaF2 68 -824.497 -9.52469 1558.569 -30.000 SiO2 70 -466.123 -8.73871 7503.078 -29.965 SiO2 72 566.609 -15.71473 -197.683 -64.000 SiO2 74-1633.285 - 17.00075 0.000W constant of the cone K and an aspheric surface coefficient C AS1 AS2 AS3 r27 (= r31) r29 (M1) r63K 0.000000 0.000000 0.000000C4 0.184947*10-8 0.820832*10-90.184651*10-8C6 0.211178*10-120.447187*10-130.427327*10-13 C8 - 0.382898*10-17 -0.564120*10-18 0.101914*10-17 C10 0.152790*10-210.229674*10-22 - 0.159307*10-22 C 12-0.561578*10-26 -0.558227*10-27 0.167653*10-26 As mentioned above, by this example, the image quantity Y had usable NA from 5 to 18.6 at 0.6, and the cata-dioptric system whose path of all optical members is about 20 was shown. Drawing 2 is the transverse aberration Fig. of the cata-dioptric system in this example, and when (a) is the image quantity Y= 18.6, it expresses the aberration in each wavelength in case (b) is the image quantity Y= 5. Aberration amendment is improved cata-dioptric system of this example very much so that drawing 2 may also show.
The [2nd example] The 1st lens group G1 is constituted from the 2nd example by the meniscus lens which turned the convex to the Rth page side of a reticle, the biconvex lens, the biconcave lens, the meniscus lens that turned the convex to the Rth page side of a reticle, and the plane-parallel plate in order [page / of reticle / Rth] moreover, the meniscus lens and biconvex lens with which the 2nd lens group turned the biconvex lens and turned the concave surface to the Rth page side of a reticle in order [page / of reticle / Rth], the meniscus lens which turned the convex to the Rth page side of a reticle, a biconcave lens, a biconvex lens, the meniscus lens that turned the convex to the Rth page side of a reticle, a biconvex lens, the meniscus lens which turned the concave surface to the Rth page side of a reticle, and negative meniscus lens LS which turned the concave surface to the Rth page side of a reticle be alike -- it ******. Here, the plane-parallel plate in the 1st lens group G1 has processed some lenses into the plane mirror M2 as an optical-path deviation member. And image

formation of the image of Reticle R is once carried out near [plane mirror M2] this. Moreover, the concave mirror M1 is formed in the aspheric surface AS 1 in this example.
[0020] The 2nd image formation optical system S2 in order [page / of reticle / Rth] Furthermore, a biconvex lens, The meniscus lens which turned the convex to the Rth page side of a reticle, the meniscus lens which turned the convex to the Rth page side of a reticle, The meniscus lens which turned the concave surface to the Rth page side of a reticle, aperture diaphragm AP, the biconvex lens in which the field by the side of Reticle R was formed to the aspheric surface AS 2, It consists of the meniscus lens which turned the convex to the Rth page side of a reticle, the biconcave lens, a meniscus lens which turned the convex to the Rth page side of a reticle, a meniscus lens which turned the convex to the Rth page side of a reticle, and a biconvex lens. He arranges a plane mirror M3 as an optical-path deviation member between the second lens in the 2nd image formation optical system S2, and the third lens, and is trying for the Rth page of a reticle and the Wth page of a wafer to become parallel by this example here between.
A field number r d ** material 0.000 45.000 R 1 281.775 18.000 SiO2 S1 G1 2 195.859 1.598 3 196.715 40.41 SiO2 4 - 480.361 14.536 5 - 548.718 20.000 SiO2 6 204.428 5.448 7 203.274 20.000 SiO2 8 401.27325.0009 0.000 35.000 SiO2 10 0.000 15.50011 303.555 30.000 CaF2 G212 -1740.057 5.92413-425.354 20.000SiO2 14 -2761.815 1.84915 300.937 40.000 CaF2 16-2581.928 1.84917288.864 20.000SiO2 18 177.975 57.22419 - 175.888 20.000 SiO2 20 764.840 0.50021 342.881 36.406 CaF2 22 -329.279 48.34123 270.936 25.000 SiO2 2 328.277 66.73225 778.30740.000 SiO2 26 -518.576 15.75327-223.579 25.000 SiO2 28 - 658.513 42.43529 - 229.025 25.000SiO(s)2 LS30 -1514.955 17.54231-332.936-17.542M1 AS 132-1514.955 -25.000SiO2 LS33 - 229.025 - 42.43534 - 658.513 -25.000 SiO2 35 -223.579 - 15.75336-518.576 - 40.000SiO2 37 778.307 - 66.73238 328.277 - 25.000 SiO2 39 270.936 - 48.34140 - 329.279-36.406 CaF2 41 342.881 - 0.50042 764.840 20.000 SiO2 43 - 175.888 - 57.22444 177.975 - 20.000 SiO2 45 288.864 - 1.84946 - 2581.928 - 40.000 CaF2 47 300.937-1.84948 - 2761.815 - 20.000 SiO2 49 - 425.354 - 5.92450 - 1740.057 - 30.000 CaF2 51303.555 - 0.50052 0.000 233.000 M253 415.20731.117CaF2 S254-631.341 0.50055 306.049 20.000 SiO2 56 218.635 150.00057 0.000-165.240 M358 -711.482-25.000 SiO2 59 - 2123.013 -302.79560 3482.765-30.000 SiO2 61 654.764 - 15.00062 0.000 - 59.904 AP 63-230.331 - 70.000 CaF2 AS264 1603.607 - 0.50065-204.918 - 28.538SiO2 66 -602.518-14.61567 1240.449 -30.000 SiO2 68 -510.567 -0.500 69 -308.492 -70.000 SiO2 70 - 714.386 -0.50071 -170.397 -45.000 SiO2 72 -62.983 -4.15673 -63.147 -62.343 SiO2 74 766.887 -17.00075 0.000 The W constant of the cone K and aspheric surface coefficient C AS1 AS2 r31 (M1) r63K 0.0000000.000000 C4 0.815186*10-90.371510*10-8C6 0.106110*10-130.507303*10-13C8 0.216157*10-18 0.416256*10-18 C10 -0.473987*10-23 0.261764*10-22 C12 0.490366*10-27 -0.397276*10-27 As mentioned above, by this example, NA was usable from the image quantity Y= 5 to 18.6 at 0.6, and the cata-dioptric system whose path of all optical members is about 20 was shown. Drawing 4 is the transverse aberration Fig. c the cata-dioptric system in this example, and (a) expresses the aberration in each wavelength in case (b) is the image quantity Y= 5 at the time of image quantity Y=18.6. Aberration amendment is improved cata-dioptric system of this example very much so that drawing 4 may also show.
[0021]
[Effect of the Invention] As mentioned above, in this invention, big numerical aperture is attained in an ultraviolet-rays wavelength region, the whole optical system has the resolution of a quarter micron unit in practical magnitude, and it became possible to offer cata-dioptric system also with still easier manufacture.

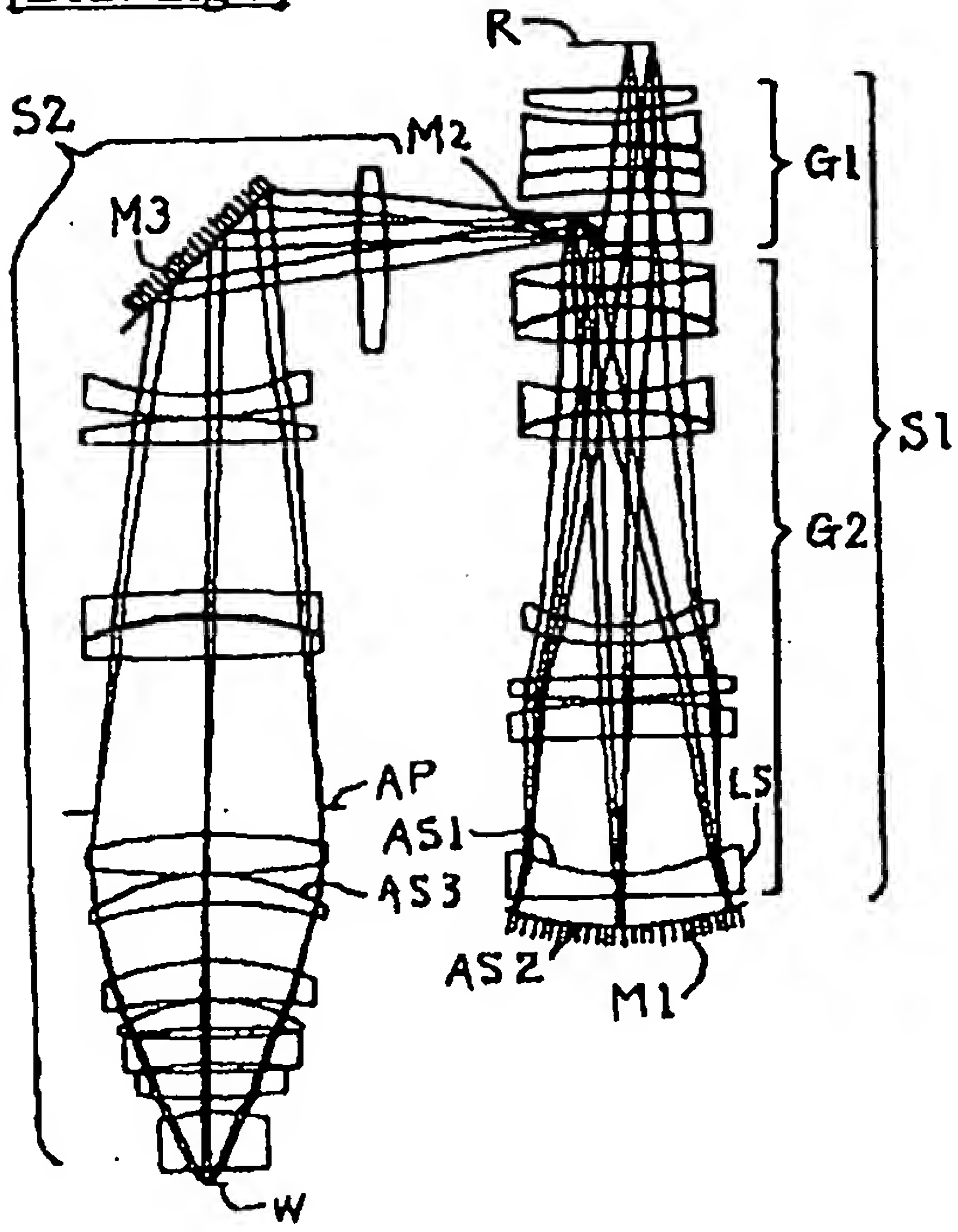
[Translation done.]

* NOTICES *

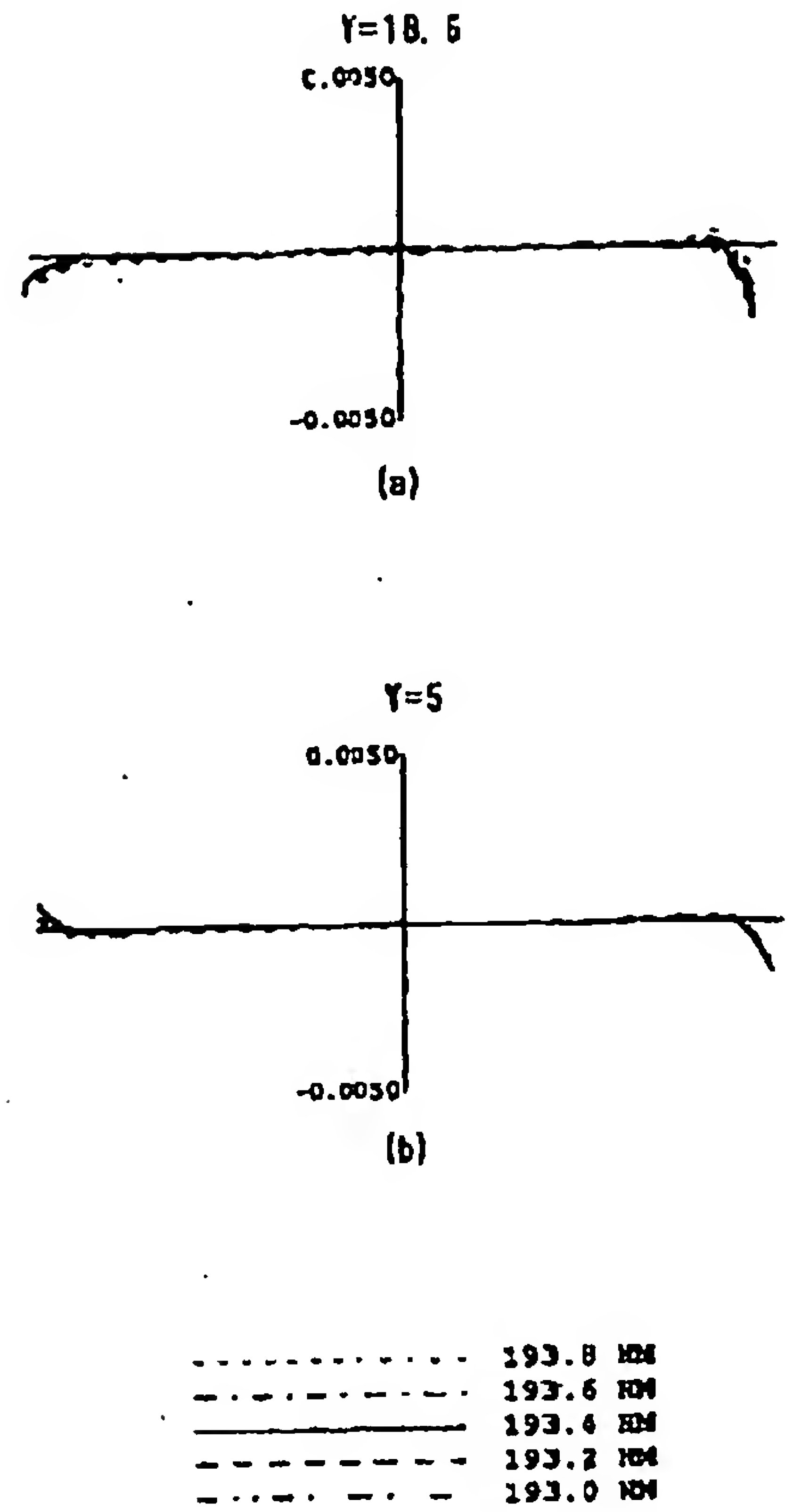
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

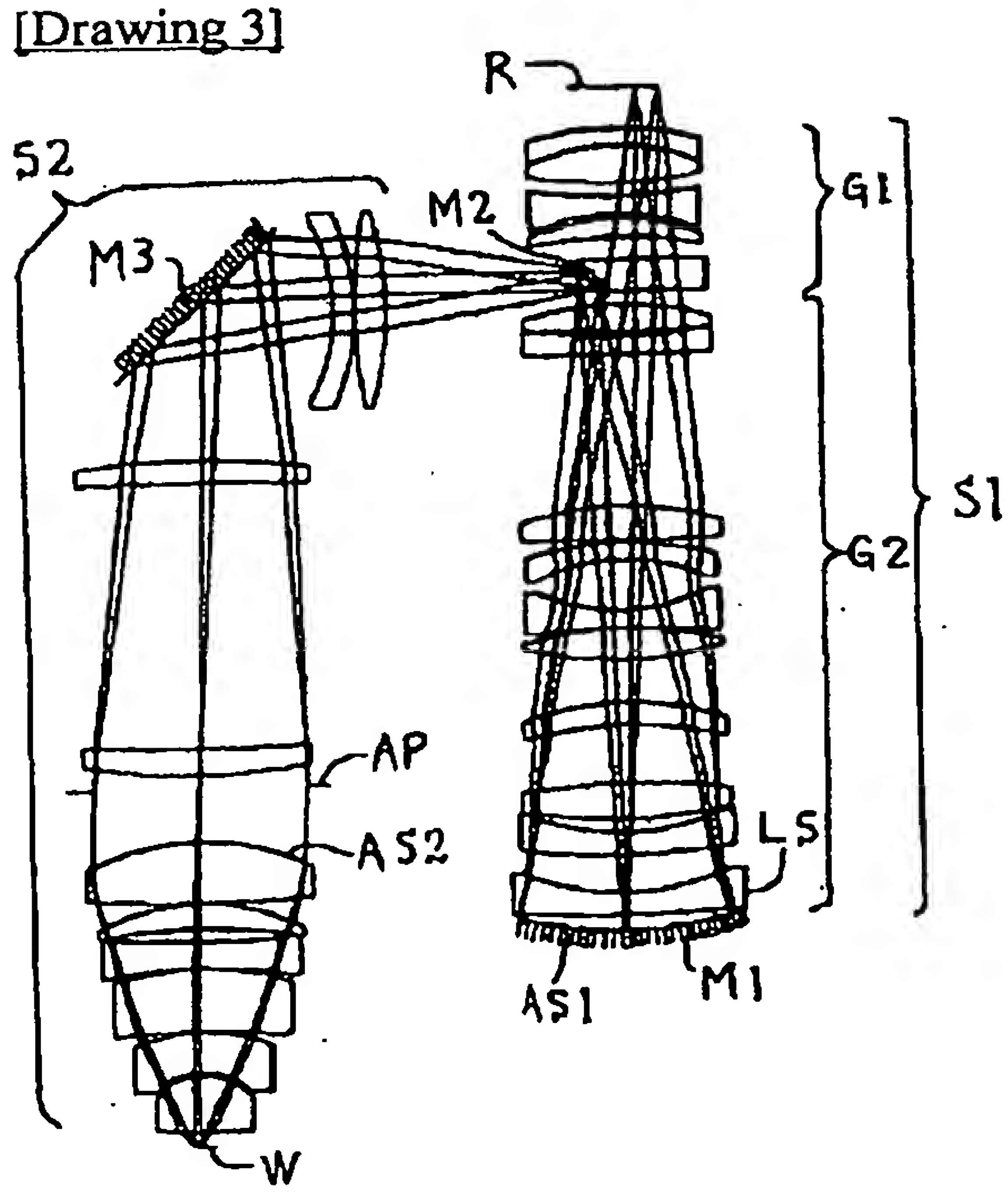
[Drawing 1]



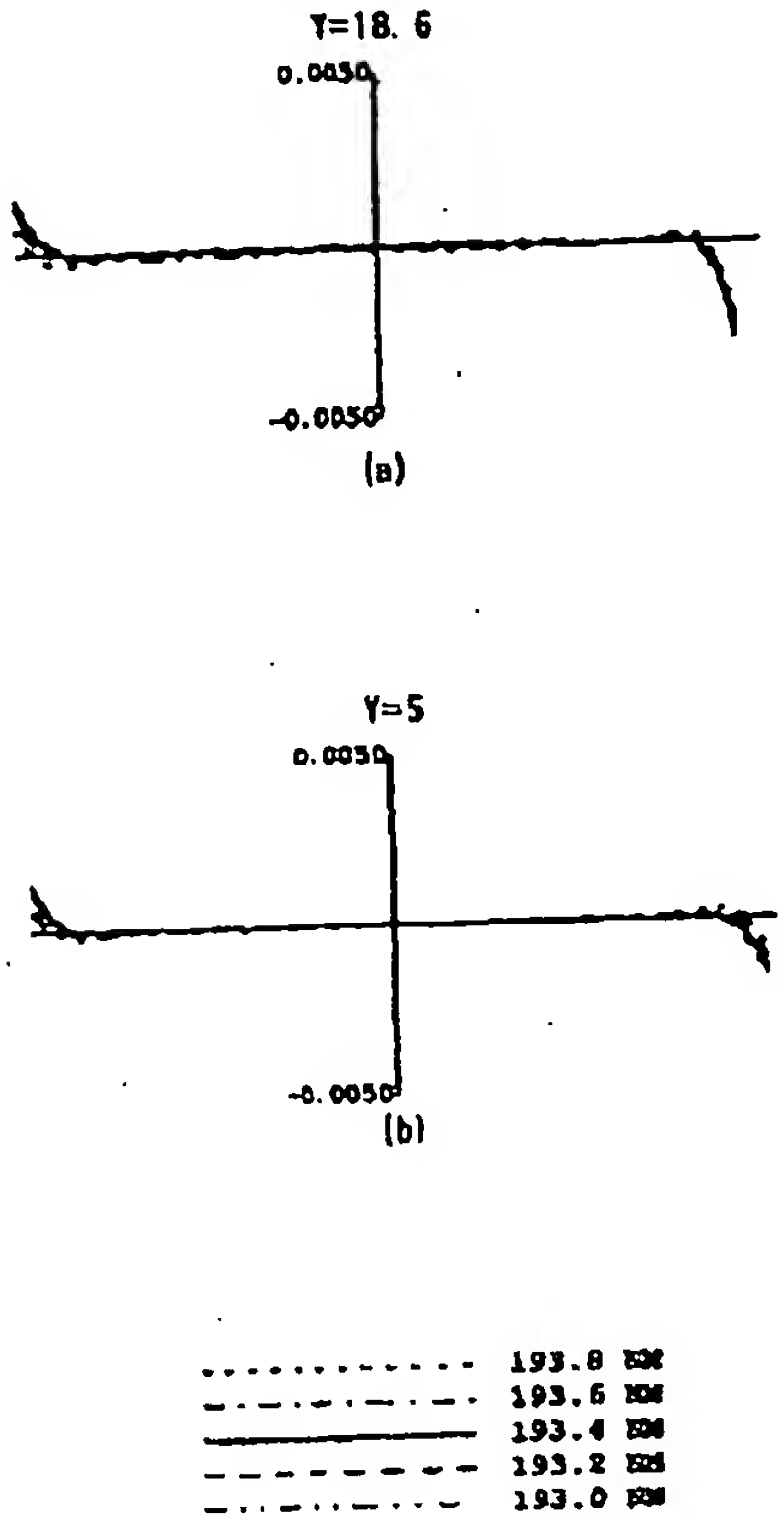
[Drawing 2]



[Drawing 3]



[Drawing 4]



[Translation done.]

CORRECTION OR AMENDMENT

[Kind of official gazette] Printing of amendment by the convention of 2 of Article 17 of Patent Law
[Section partition] The 2nd partition of the 6th section
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G02B 13/18
G02F 1/13
G03F 7/20
H01L 21/027

[FI]

G02B 17/08		A
G02B 13/18		
G02F 1/13	101	
G03F 7/20	521	
H01L 21/30	515	D
H01L 21/30	517	

[Procedure revision]
[Filing Date] October 28, Heisei 15 (2003. 10.28)
[Procedure amendment 1]
[Document to be Amended] Specification
[Item(s) to be Amended] The name of invention
[Method of Amendment] Modification
[The contents of amendment]
[Title of the Invention] Cata-dioptric system, a projection aligner, and the projection exposure approach
[Procedure amendment 2]
[Document to be Amended] Specification
[Item(s) to be Amended] Claim
[Method of Amendment] Modification
[The contents of amendment]
[Claim(s)]
[Claim 1]
In the cata-dioptric system which projects the pattern of a semiconductor device on the order in which a bean of light advances to up to a substrate including the 1st image formation optical system constituted by the refraction member, a concave mirror, and the 2nd image formation optical system constituted by the refractio member,

It is the cata-dioptric system characterized by at least one refraction member having the aspheric surface amor the refraction members which constitute the refraction member which constitutes said 1st image formation optical system, and said 2nd image formation optical system.

[Claim 2]

Said 1st image formation optical system consists of the 1st lens group which a beam of light passes only at once, and the 2nd lens group to which a beam of light goes and comes back,
The lens nearest to a concave mirror of this 2nd lens group is a negative lens,
The beam of light which injected said 2nd lens group is cata-dioptric system according to claim 1 characterize by carrying out image formation of the pattern of said semiconductor device once before carrying out incidenc to said 2nd image formation optical system.

[Claim 3]

Cata-dioptric system according to claim 1 or 2 characterized by having arranged the optical-path deviation member between said 1st image formation optical system and said 2nd image formation optical system.

[Claim 4]

The refraction member which constitutes the refraction member which constitutes said 1st image formation optical system, and said 2nd image formation optical system is the cata-dioptric system of three claim 1 characterized by being constituted by a quartz and fluorite, or any its one ** material thru/or given in any 1 term.

[Claim 5]

Said concave mirror is the cata-dioptric system of four claim 1 characterized by being an aspheric surface configuration thru/or given in any 1 term.

[Claim 6]

In the cata-dioptric system which exposes the pattern image of a reticle on a substrate,
The 1st image formation optical system which has a refraction member and a concave mirror,
It is arranged in the optical path between said 1st image formation optical system and said substrates, and has the 2nd image formation optical system which has a refraction member,
It is the cata-dioptric system characterized by at least one refraction member having the aspheric surface amo the refraction members which constitute said 1st and 2nd image formation optical system.

[Claim 7]

Said 1st image formation optical system is equipped with the 1st lens group arranged in the optical path between said reticles and said concave mirrors, and the 2nd lens group arranged in the optical path between th 1st lens group and said concave mirror,
In said 1st lens group, a beam of light passes only at once, and a beam of light carries out both-way passage at said 2nd lens group,
Said 2nd lens group equips said concave mirror with the negative lens by which contiguity arrangement is carried out most,
Cata-dioptric system according to claim 6 characterized by forming the middle image of said reticle into the optical path between said 1st image formation optical system and said 2nd image formation optical system.

[Claim 8]

Said 2nd lens group is cata-dioptric system according to claim 7 characterized by having the refraction memb with at least two different negative refractive power, and the refraction member with at least two different forward refractive power.

[Claim 9]

Said 1st lens group is cata-dioptric system according to claim 8 characterized by having the refraction membe with at least three different refractive power.

[Claim 10]

The refraction member with said at least three different refractive power in said 1st lens group is cata-dioptric system according to claim 9 characterized by having the lens for adjustment.

[Claim 11]

Claim 6 characterized by having further the optical-path deviation member arranged in the optical path betwe said 1st image formation optical system and said 2nd image formation optical system thru/or cata-dioptric system of ten given in any 1 term.

[Claim 12]

The refraction member which constitutes said 1st and 2nd image formation optical system is the cata-dioptric system of 11 claim 6 characterized by being constituted with a quartz and fluorite, or any its one ingredient thru/or given in any 1 term.
[Claim 13]
Said concave mirror is the cata-dioptric system of 12 claim 6 characterized by having an aspheric surface configuration thru/or given in any 1 term.
[Claim 14]
Said 2nd image formation optical system is the cata-dioptric system of 13 claim 6 characterized by having the variable aperture thru/or given in any 1 term.
[Claim 15]
In the projection aligner which exposes the image of a reticle on a substrate through projection optics,
The projection aligner characterized by having claim 1 for imprinting the image of said reticle on said substrat thru/or the cata-dioptric system of 14 given in any 1 term.
[Claim 16]
In the projection exposure approach which exposes the image of a reticle on a substrate through projection optics,
The projection exposure approach characterized by imprinting the image of said reticle on a substrate using th cata-dioptric system of 14 claim 1 thru/or given in any 1 term.
[Procedure amendment 3]
[Document to be Amended] Specification
[Item(s) to be Amended] 0001
[Method of Amendment] Modification
[The contents of amendment]
[0001]
[Field of the Invention]
This invention relates to the projection exposure approach using the projection aligner using the cata-dioptric system and this cata-dioptric system which have the resolution of a quarter micron unit in an ultraviolet-rays wavelength region, and this cata-dioptric system the optical system used with the projection aligner used in ca a semiconductor device or a liquid crystal display component is manufactured at a photolithography process, and by using a reflecting mirror as an element of optical system especially.
[Procedure amendment 4]
[Document to be Amended] Specification
[Item(s) to be Amended] 0007
[Method of Amendment] Modification
[The contents of amendment]
[0007]
In view of this point, this invention attains big numerical aperture in an ultraviolet-rays wavelength region, th whole optical system is practical magnitude, and it has the resolution of a quarter micron unit, and aims at offering the projection exposure approach using the projection aligner using the cata-dioptric system and this cata-dioptric system which miniaturized each configuration member of optical system, and this cata-dioptric system.
[Procedure amendment 5]
[Document to be Amended] Specification
[Item(s) to be Amended] 0021
[Method of Amendment] Modification
[The contents of amendment]
[0021]
[Effect of the Invention]
As mentioned above, by this invention, big numerical aperture was attained in the ultraviolet-rays wavelength region, and in practical magnitude, the whole optical system has the resolution of a quarter micron unit, and became possible [offering the projection exposure approach using the projection aligner using cata-dioptric system also with still easier manufacture and this cata-dioptric system, and this cata-dioptric system].

[Translation done.]

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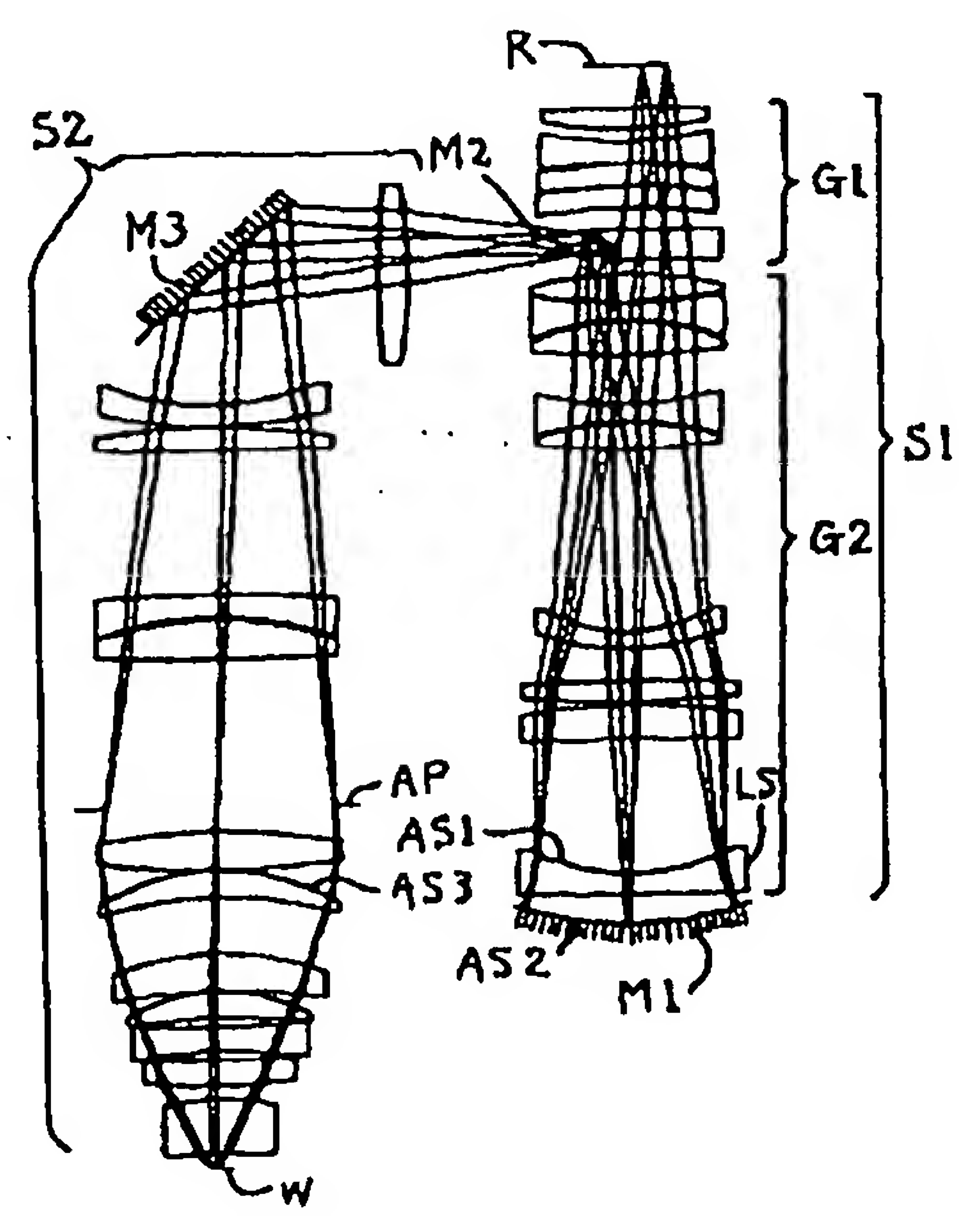
(54)【発明の名称】　反射屈折光学系

(57)【要約】
【課題】紫外線波長域で大きな開口数を達成し、光学系全体が実用的な大きさで、クオーターミクロン単位の解像度を有し、光学系の各構成部材を小型化した反射屈折光学系を提供する。
【解決手段】光線が進行する順に、屈折部材によって構成された第１結像光学系Ｓ１と、凹面鏡Ｍ１と、屈折部材によって構成された第２結像光学系Ｓ２とを含み、半導体素子のパターンを基板上へ投影する反射屈折光学系において、前記第１結像光学系を構成する屈折部材及び前記第２結像光学系を構成する屈折部材のうち、少なくとも１つの屈折部材は非球面を有する反射屈折光学系を提供する。



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【特許請求の範囲】

【請求項１】光線が進行する順に、屈折部材によって構成された第１結像光学系と、凹面鏡と、屈折部材によって構成された第２結像光学系とを含み、半導体素子のパターンを基板上へ投影する反射屈折光学系において、

前記第１結像光学系を構成する屈折部材及び前記第２結像光学系を構成する屈折部材のうち、少なくとも１つの屈折部材は非球面を有することを特徴とする反射屈折光学系。

【請求項２】前記第１結像光学系は、光線が一度だけ通過する第１レンズ群と、光線が往復する第２レンズ群とからなり、

該第２レンズ群の最も凹面鏡に近いレンズは、負レンズであり、

前記第２レンズ群を射出した光線は、前記第２結像光学系に入射する前に前記半導体素子のパターンを一度結像することを特徴とする請求項１記載の反射屈折光学系。

【請求項３】前記第１結像光学系と前記第２結像光学系との間に光路偏向部材を配置したことを特徴とする請求項１又は２記載の反射屈折光学系。

【請求項４】前記第１結像光学系を構成する屈折部材及び前記第２結像光学系を構成する屈折部材は、石英及び蛍石、またはその何れか１つの硝材により構成されることを特徴とする請求項１乃至３記載の反射屈折光学系。

【請求項５】前記凹面鏡は非球面形状であることを特徴とする請求項１乃至４記載の反射屈折光学系。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、例えば半導体素子、または液晶表示素子等をフォトリソグラフィ工程で製造する際に使用される投影露光装置で用いられる光学系に関する。特に、光学系の要素として反射鏡を用いることにより、紫外線波長域でクオーターミクロン単位の解像度を有する反射屈折光学系に関する。

【０００２】

【従来の技術】半導体素子等を製造するためのフォトグラフィ工程において、半導体素子のパターンが描かれたフォトマスクまたはレチクル（以下、まとめてレチクルと称する）を投影光学系を介して、フォトレジスト等が塗布されたウエハーまたはガラスプレート等の基板（以下、まとめてウエハーと称する）上に露光する投影露光装置が使用されている。半導体素子等の集積度が向上するにつれて、投影露光装置に使用されている投影光学系に要求される解像力は益々高まっている。この要求を満足するために、照明光の波長を短く且つ投影光学系の開口数（ＮＡ）を大きくする必要が生じた。これら要求を満たすために、反射系と屈折系とを組み合わせた所謂反射屈折光学系で投影光学系を構成する種々の技術が提案されている。

【０００３】例えば、特開昭６３－１６３３１９号公報

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及び特公平５－２５１７０号公報には、光軸上の光線を含む露光領域を用いる反射屈折光学系が開示されている。また、光軸上を用いず輪帯状の露光領域を用いる光学系としては、特公平７－１１１５１２号公報及びＵＳＰ－４，７７９，９６６号に開示された光学系がある。

【０００４】

【発明が解決しようとする課題】上記の光軸上の光線を含む露光領域を用いる反射屈折光学系では、光路分割のために透過反射面を持ったビームスプリッターを使う必要がある。このような光学系ではウエハー面からの反射光による内面反射や、ビームスプリッター以降の光学系の屈折面での内面反射、ビームスプリッターの透過反射面等において、フレアーや照明ムラの原因となる迷光が発生し易い。また開口数を大きくすると大型のビームスプリッターが必要となり、光量ロスによる露光時間の長大化は半導体製造工程におけるスループットの低下を招く。さらに特開平６－３００９７３号公報等にも開示されているように、光量ロスを防ぐ為に偏光ビームスプリッターの採用が必要となるが、大型の偏光ビームスプリッターを製造することは極めて難しく、透過反射膜の不均一性、角度特性、吸収、位相変化などが結像特性を劣化させるという不都合があった。

【０００５】一方、輪帯状の露光領域を用いるＵＳＰ－４，７７９，９６６号に開示された反射屈折光学系では、反射光学系を中間像よりもウエハー面よりの縮小側に採用している。しかし縮小側はレチクル面側に比べてＮＡが大きいため、光路分割が困難で光学系のＮＡを大きくすることができず、十分な解像力を持つことができない。また凹面鏡の大型化も避けられない。

【０００６】同様に輪帯状の露光領域を用いる特公平７－１１１５１２号公報に開示された反射屈折光学系では、中間像を形成するための凹面鏡を含む第１結像光学系が完全対称型の光学系で構成されており、中間像はレチクル面の等倍像となっている。これにより第１結像光学系の収差発生を軽減させているが、第２結像光学系が全系の倍率を一手に受け持つこととなり、第２結像光学系にかかる負担が重くなる。特に光学系に大きなＮＡが要求されると、第２結像光学系の大型化、複雑化は避けられない。

【０００７】本発明は斯かる点に鑑み、紫外線波長域で大きな開口数を達成し、光学系全体が実用的な大きさで、クオーターミクロン単位の解像度を有し、光学系の各構成部材を小型化した反射屈折光学系を提供することを目的とする。

【０００８】

【課題を解決するための手段】上述の目的を達成するために、本発明では、光線が進行する順に、屈折部材によって構成された第１結像光学系Ｓ１と、凹面鏡Ｍ１と、屈折部材によって構成された第２結像光学系Ｓ２とを含み、半導体素子のパターンを基板上へ投影する反射屈折

光学系において、前記第１結像光学系を構成する屈折部材及び前記第２結像光学系を構成する屈折部材のうち、少なくとも１つの屈折部材は非球面を有することを特徴とする反射屈折光学系を提供する。

【０００９】

【発明の実施の形態】上述の様に本発明においては、屈折部材に非球面形状を採用することで、高次収差の発生を軽減すること及び光学系のＮＡを大きくすることが可能となり、光学系の大型化、複雑化を防ぐことができる。これは、屈折面を球面からずらすことにより、レンズ面周辺の光束を理想的に曲げることができるようになる。それによって、光束全体を広げずに、高次の収差補正ができるようになるからである。

【００１０】特に、第１結像光学系Ｓ１に非球面形状の屈折面を導入すると、第１結像光学系Ｓ１の大型化を防ぐことができ、第２結像光学系Ｓ２に非球面形状の屈折面を導入すると、第２結像光学系Ｓ２の大型化を防ぐことができる。また、本発明では、第１結像光学系Ｓ１は、光線が一度だけ通過する第１レンズ群Ｇ１と、光線が往復する第２レンズ群Ｇ２とからなり、第２レンズ群Ｇ２の最も凹面鏡Ｍ１に近いレンズは、負レンズＬＳであり、第２レンズ群Ｇ２を射出した光線は、第２結像光学系Ｓ２に入射する前に半導体素子のパターンを一度結像することが好ましい。特にこのような光学系の配置にすると、各構成部材の小型化が達成できる。その上、光線の進行する順に、第２レンズ群Ｇ２の最も凹面鏡Ｍ１に近いレンズを負レンズＬＳ、凹面鏡Ｍ１、第２結像光学系Ｓ２と配置し、第２レンズ群Ｇ２を射出した光線が第２結像光学系Ｓ２に入射する前に半導体素子のパターンを一度結像するという構成は、軸上色収差の低減に非常に有効である。

【００１１】上述の様な構成の光学系の場合は、更に、第２レンズ群Ｇ２が少なくとも２つの異なる負の屈折力を持つ屈折部材と、少なくとも２つの異なる正の屈折力を持つ屈折部材から構成されることが好ましい。負の屈折力を持つレンズは、コマ収差や球面収差、像面湾曲等の補正に大いに有効であり、正の屈折力を持つレンズは光学系が大きくなることなく、大きなＮＡや大きな露光領域を持つために有効である。さらに、第２結像光学系Ｓ２の収差を補償し、第２結像光学系Ｓ２の収差補正の負担を軽くするためには少なくとも各々２つずつのレンズを有することが望ましい。

【００１２】そして、更に、第１レンズ群Ｇ１は、少なくとも３つの異なる屈折力を持つ屈折部材から構成されることが好ましい。近時、光学系に解像力が求められるにつれて、歪曲収差の補正や像面湾曲の補正も厳しいスペックが要求されている。この達成のためには、製造時の調整が必要となるが、調整用のレンズはレチクル面近傍のレンズが有効である。しかし本発明の光学系の第２レンズ群Ｇ２は、往復兼用光学系であるため、調整用の

レンズとしては不向きといえる。従って、第１レンズ群Ｇ１に少なくとも３つの異なる屈折力を持つレンズで構成することにより、歪曲収差や像面湾曲の製造時の調整が可能となる。また、上記の構成に第１レンズ群Ｇ１をすることで、レチクルＲ面付近でのワーキングディスタンスを大きくすることが可能となり、ステップ・アンド・スキャン方式の露光を実現できる。

【００１３】また、第２結像光学系Ｓ２は、主に球面収差やコマ収差を補正し、光学系が大きなＮＡを持つための重要な役割を果たす。本発明では、第１結像光学系Ｓ１と第２結像光学系Ｓ２との間に、光路偏向部材Ｍ３を配置することが好ましい。これは、ミラー等の光路偏向部材を配置することによって、光学系全体を折り曲げることが可能になり、光学系全体の小型化を達成することができるためである。

【００１４】また、本発明では、波長が３００ｎｍを越えた短波長を露光用の光源として使用するため、特に、この領域での光量透過特性が良く、経済的で、加工性の良い石英か蛍石を使用することが好ましい。また、本発明では、凹面鏡Ｍ１を非球面形状に形成しても構わない。凹面鏡Ｍ１が非球面形状であると、高次収差の発生なく凹面鏡Ｍ１の持つ正の屈折力を大きくすることができ、光学系の小型化及び大ＮＡ化の実現、さらに広帯域の波長についての色収差補正が可能となる。

【００１５】尚、第２結像光学系Ｓ２の光路中に開口絞り（可変絞り）を設けることで、コヒーレンスファクタ（σ値）を調整できる。焦点深度を深くして且つ解像力を上げる一つの手法として、例えば特公昭６２－５０８１１号公報において、レチクルのパターン中の所定部分の位相を他の部分からずらす位相シフト法が提案されている。本発明においては、コヒーレンスファクタ（σ値）を調整することが可能であるため、この位相シフト法の効果をさらに向上できる利点がある。

【００１６】

【実施例】以下に本発明による反射屈折光学系の数値実施例を示す。各数値実施例による反射屈折光学系は、レチクルＲ側から順に（光線が進行する順に）、屈折部材によって構成された第１結像光学系Ｓ１、凹面鏡Ｍ１、屈折部材によって構成された第２結像光学系Ｓ２とによって構成され、第１結像光学系Ｓ１は、光線が一度だけ通過する第１レンズ群Ｇ１と光線が往復する第２レンズ群Ｇ２とからなり、第２レンズ群の最も凹面鏡Ｍ１に近いレンズは、負レンズＬＳで構成されている。

【００１７】また、各数値実施例とも、ＮＡ＝０．６で、像高が５から１８．６までの範囲で収差補正がなされている。尚、露光領域としては、前述の像高の範囲を輪帯状にしてもよいし、光軸から５離れたところに６×３０の長方形にしてもよい。第１実施例及び第２実施例の各表中、ｒは面の曲率半径を表し、ｄは面の間隔を表している。また、硝材として、石英はSiO_2と、蛍石

はCaF₂と各表中記載してある。石英及び蛍石の193．0nmに対する屈折率n及び±0．1nmに対する分散値1／νは、次の通りである。

【0018】

	n	1／ν
合成石英 ：	1．56019	1780
蛍石 ：	1．50138	2550

また、各実施例中、非球面は、以下の式によって表されるものである。

$Z=(Y^2/r)/[1+\mathrm{sqrt}\{1-(1+K)Y^2/r^2\}]+C_4Y^4+C_6Y^6+C_8Y^8+C_{10}Y^{10}+C_{12}Y^{12}$

但し、 Z ： 頂点より光軸方向に測った距離
Y ： 頂点より光軸に垂直な方向に測った距離
K ： 円錐係数
r ： 頂点の曲率半径
C_4、C_6、C_8・・・ ： 4次、6次、8次・・・の非球面係数

〔第1実施例〕第1実施例では、第1レンズ群G1は、レチクルR面より順に、両凸レンズ、両凹レンズ、レチクルR面側に凸面を向けたメニスカスレンズ、レチクルR面側に凸面を向けたメニスカスレンズ、平行平面板によって構成されている。また、第2レンズ群は、レチクルR面より順に、両凸レンズ、両凹レンズ、両凸レンズ、両凹レンズ、両凸レンズ、レチクルR面側に凹面を＊向けたメニスカスレンズ、両凸レンズ、レチクルR面側に凸面を向けたメニスカスレンズ、レチクルR側の面を非球面AS1に形成したレチクルR面側に凹面を向けた負メニスカスレンズLSによって構成されている。ここで、第1レンズ群G1の中の平行平面板は、レンズの一部を、光路偏向部材として平面鏡M2に加工している。そして、この平面鏡M2付近で、一度レチクルRの像を結像する。また、本実施例中では、凹面鏡M1は、非球面AS2に形成している。

【0019】更に、第2結像光学系S2は、レチクルR面より順に、両凸レンズ、レチクルR面側に凹面を向けたメニスカスレンズ、両凸レンズ、レチクルR面側に凸面を向けたメニスカスレンズ、両凸レンズ、開口絞りAP、両凸レンズ、レチクルR側の面を非球面AS3に形成したレチクルR面側に凸面を向けたメニスカスレンズ、レチクルR面側に凸面を向けたメニスカスレンズ、レチクルR面側に凸面を向けたメニスカスレンズ、両凹レンズ、レチクルR面側に凹面を向けたメニスカスレンズ、レチクルR面側に凸面を向けたメニスカスレンズから構成されている。ここで、本実施例では、第2結像光学系S2の中の一番目のレンズと二番目のレンズとの間に、光路偏向部材として平面鏡M3を配置して、レチクルR面とウェハーW面とが平行になるようにしている。

面番号	r	d	硝材		
	0.000	50.000		R	
1	1827.099	25.000	SiO_2	S1	G1
2	-391.019	13.420			
3	-396.812	25.000	SiO_2		
4	829.284	1.000			
5	459.609	25.000	SiO_2		
6	745.296	1.000			
7	488.042	25.000	SiO_2		
8	586.033	25.000			
9	0.000	35.000	SiO_2		
10	0.000	16.000			
11	361.664	32.175	CaF_2		G2
12	-449.989	1.000			
13	-561.169	20.000	SiO_2		
14	255.230	1.000			
15	223.249	39.738	CaF_2		
16	-756.196	57.483			
17	-315.859	20.000	SiO_2		
18	299.543	1.000			
19	260.236	32.584	CaF_2		
20	-675.594	211.188			
21	-163.356	20.000	SiO_2		
22	-252.267	38.241			
23	2280.139	25.000	SiO_2		

24	-1082.014	3.367			
25	556.937	40.000	SiO_2		
26	4236.526	156.695			
27	-215.826	25.000	SiO_2	LS	AS1
28	-4417.336	33.561			
29	-354.342	-33.561		M1	AS2
30	-4417.336	-25.000	SiO_2	LS	
31	-215.826	-156.695			AS1
32	4236.526	-40.000	SiO_2		
33	556.937	-3.367			
34	-1082.014	-25.000	SiO_2		
35	2280.139	-38.241			
36	-252.267	-20.000	SiO_2		
37	-163.356	-211.188			
38	-675.594	-32.584	CaF_2		
39	260.236	-1.000			
40	299.543	-20.000	SiO_2		
41	-315.859	-57.483			
42	-756.196	-39.738	CaF_2		
43	223.249	-1.000			
44	255.230	-20.000	SiO_2		
45	-561.169	-1.000			
46	-449.989	-32.175	CaF_2		
47	361.664	-5.000			
48	0.000	235.151		M2	
49	687.782	30.000	SiO_2	S2	
50	-1403.174	170.000			
51	0.000	-150.026		M3	
52	262.520	-25.000	SiO_2		
53	474.401	-1.304			
54	-632.711	-27.786	SiO_2		
55	5490.382	-168.081			
56	-1783.259	-25.000	SiO_2		
57	-321.439	-4.402			
58	-357.850	-44.750	CaF_2		
59	3152.678	-173.787			
60	0.000	-28.467		AP	
61	-566.009	-45.000	CaF_2		
62	806.950	-1.000			
63	-212.463	-31.096	CaF_2	AS3	
64	-368.988	-65.190			
65	-260.201	-44.295	SiO_2		
66	-544.105	-1.000			
67	-169.071	-31.373	CaF_2		
68	-824.497	-9.524			
69	1558.569	-30.000	SiO_2		
70	-466.123	-8.738			
71	7503.078	-29.965	SiO_2		
72	566.609	-15.714			
73	-197.683	-64.000	SiO_2		

74	-1633.285	-17.000	
75	0.000		W

円錐係数K及び非球面係数C

	AS1 r27 (=r31)	AS2 r29 (M1)	AS3 r63
K	0.000000	0.000000	0.000000
C_4	$0.184947*10^{-8}$	$0.820832*10^{-8}$	$0.184651*10^{-8}$
C_6	$0.211178*10^{-13}$	$0.447187*10^{-13}$	$0.427327*10^{-13}$
C_8	$-0.382898*10^{-17}$	$-0.564120*10^{-18}$	$0.101914*10^{-17}$
C_{10}	$0.152790*10^{-21}$	$0.229674*10^{-22}$	$-0.159307*10^{-22}$
C_{12}	$-0.561578*10^{-26}$	$-0.558227*10^{-27}$	$0.167653*10^{-26}$

以上の様に、本実施例では、NAが0．6で像高Yが5から18．6まで使用可能で、全ての光学部材の径が20程度の反射屈折光学系を示した。図2は、本実施例での反射屈折光学系の横収差図であり、（a）が像高Y＝18．6のとき、（b）が像高Y＝5のときの各波長での収差を表している。図2からも分かるように本実施例の反射屈折光学系は、非常に良く収差補正されている。

〔第2実施例〕第2実施例では、第1レンズ群G1は、レチクルR面より順に、レチクルR面側に凸面を向けたメニスカスレンズ、両凸レンズ、両凹レンズ、レチクルR面側に凸面を向けたメニスカスレンズ、平行平面板によって構成されている。また、第2レンズ群は、レチクルR面より順に、両凸レンズ、レチクルR面側に凹面を向けたメニスカスレンズ、両凸レンズ、レチクルR面側に凸面を向けたメニスカスレンズ、両凹レンズ、両凸レンズ、レチクルR面側に凸面を向けたメニスカスレンズ、両凸レンズ、レチクルR面側に凹面を向けたメニスカスレンズ、レチクルR面側に凹面を向けた負メニスカスレンズL_2によって構成されている。ここで、第1レンズ群G1の中の平行平面板は、レンズの一部を、光路偏向部材として平面鏡M2に加工している。そして、この平面鏡M2付近で、一度レチクルRの像を結像する。また、本実施例中では、凹面鏡M1は、非球面AS1に形成している。

【0020】更に、第2結像光学系S2は、レチクルR面より順に、両凸レンズ、レチクルR面側に凸面を向けたメニスカスレンズ、レチクルR面側に凸面を向けたメニスカスレンズ、レチクルR面側に凹面を向けたメニスカスレンズ、開口絞りAP、レチクルR側の面を非球面AS2に形成した両凸レンズ、レチクルR面側に凸面を向けたメニスカスレンズ、両凹レンズ、レチクルR面側に凸面を向けたメニスカスレンズ、レチクルR面側に凸面を向けたメニスカスレンズ、両凸レンズから構成されている。ここで、本実施例では、第2結像光学系S2の中の二番目のレンズと三番目のレンズとの間に、光路偏向部材として平面鏡M3を配置して、レチクルR面とウェハーW面とが平行になるようにしている。

面番号	r	d	硝材		
	0.000	45.000		R	
1	281.775	18.000	SiO_2	S1	G1
2	195.859	1.598			
3	196.715	40.418	SiO_2		
4	-480.361	14.536			
5	-548.718	20.000	SiO_2		
6	204.428	5.448			
7	203.274	20.000	SiO_2		
8	401.273	25.000			
9	0.000	35.000	SiO_2		
10	0.000	15.500			
11	303.555	30.000	CaF_2		G2
12	-1740.057	5.924			
13	-425.354	20.000	SiO_2		
14	-2761.815	1.849			
15	300.937	40.000	CaF_2		
16	-2581.928	1.849			
17	288.854	20.000	SiO_2		
18	177.975	57.224			

19	-175.888	20.000	SiO_2		
20	764.840	0.500			
21	342.881	36.406	CaF_2		
22	-329.279	48.341			
23	270.936	25.000	SiO_2		
24	328.277	66.732			
25	778.307	40.000	SiO_2		
26	-518.576	15.753			
27	-223.579	25.000	SiO_2		
28	-658.513	42.435			
29	-229.025	25.000	SiO_2	LS	
30	-1514.955	17.542			
31	-332.936	-17.542		M1	AS1
32	-1514.955	-25.000	SiO_2	LS	
33	-229.025	-42.435			
34	-658.513	-25.000	SiO_2		
35	-223.579	-15.753			
36	-518.576	-40.000	SiO_2		
37	778.307	-66.732			
38	328.277	-25.000	SiO_2		
39	270.936	-48.341			
40	-329.279	-36.406	CaF_2		
41	342.881	-0.500			
42	764.840	-20.000	SiO_2		
43	-175.888	-57.224			
44	177.975	-20.000	SiO_2		
45	288.864	-1.849			
46	-2581.928	-40.000	CaF_2		
47	300.937	-1.849			
48	-2761.815	-20.000	SiO_2		
49	-425.354	-5.924			
50	-1740.057	-30.000	CaF_2		
51	303.555	-0.500			
52	0.000	233.000		M2	
53	415.207	31.117	CaF_2	S2	
54	-631.341	0.500			
55	306.049	20.000	SiO_2		
56	218.635	150.000			
57	0.000	-165.240		M3	
58	-711.482	-25.000	SiO_2		
59	-2123.013	-302.795			
60	3482.765	-30.000	SiO_2		
61	654.764	-15.000			
62	0.000	-59.904		AP	
63	-230.331	-70.000	CaF_2	AS2	
64	1603.607	-0.500			
65	-204.918	-28.538	SiO_2		
66	-602.518	-14.615			
67	1240.449	-30.000	SiO_2		
68	-510.567	-0.500			

６９	−308.492	−70.000	SiO_2
７０	−714.386	−0.500	
７１	−170.397	−45.000	SiO_2
７２	−62.983	−4.156	
７３	−63.147	−62.343	SiO_2
７４	766.887	−17.000	
７５	0.000		W

円錐係数Ｋ及び非球面係数Ｃ

	ＡＳ１ ｒ３１（Ｍ１）	ＡＳ２ ｒ６３
K	0.000000	0.000000
C_4	$0.815186 * 10^{-9}$	$0.371510 * 10^{-8}$
C_6	$0.106110 * 10^{-13}$	$0.507303 * 10^{-13}$
C_8	$0.216157 * 10^{-18}$	$0.416256 * 10^{-18}$
C_{10}	$-0.473987 * 10^{-22}$	$0.261764 * 10^{-22}$
C_{12}	$0.490366 * 10^{-27}$	$-0.397276 * 10^{-27}$

以上の様に、本実施例では、ＮＡが０．６で像高Ｙ＝５から１８．６まで使用可能で、全ての光学部材の径が２０程度の反射屈折光学系を示した。図４は、本実施例での反射屈折光学系の横収差図であり、（ａ）が像高Ｙ＝１８．６とき、（ｂ）が像高Ｙ＝５のときの各波長での収差を表している。図４からも分かるように本実施例の反射屈折光学系は、非常に良く収差補正されている。

【００２１】

【発明の効果】以上のように、本発明では、紫外線波長域で大きな開口数を達成し、光学系全体が実用的な大きさで、クオーターミクロン単位の解像度を有し、更に製造も容易な反射屈折光学系を提供することが可能になった。

【図面の簡単な説明】

【図１】図１は、第１実施例の反射屈折光学系の構成図である。

【図２】図２は、第１実施例の反射屈折光学系の収差図である。

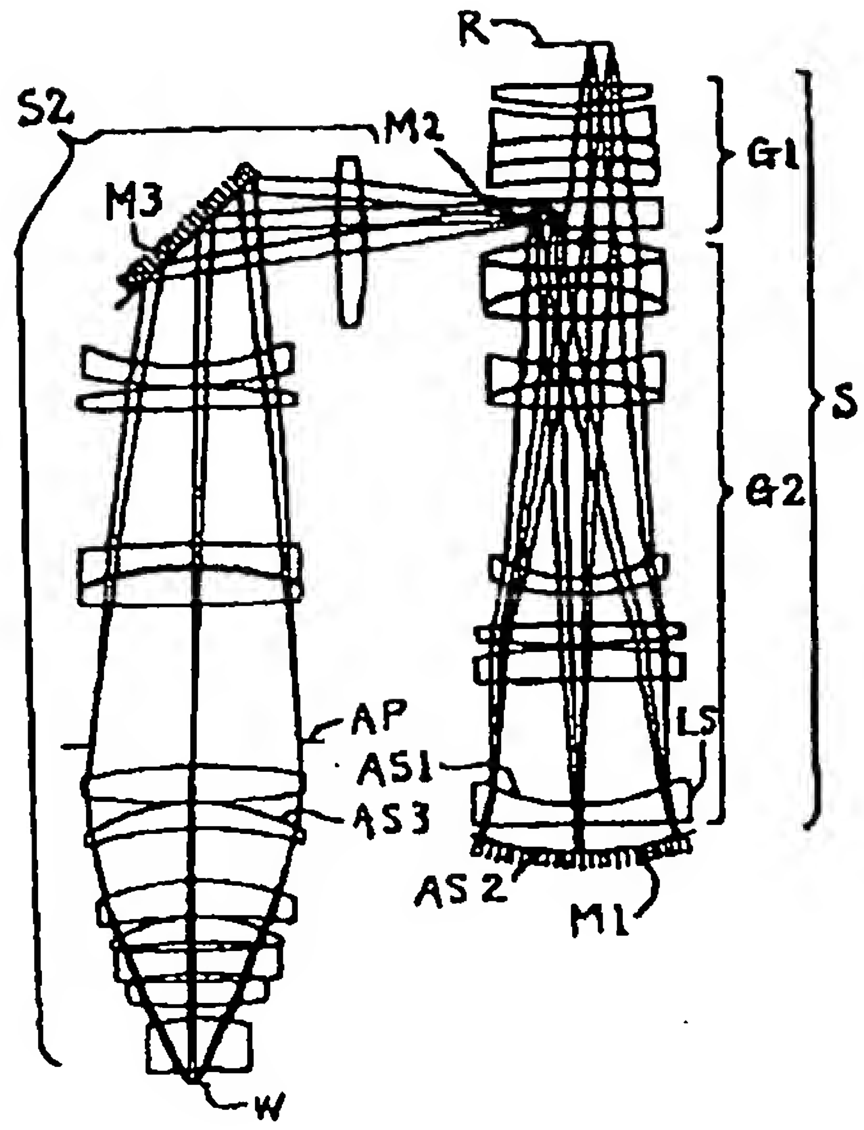
【図３】図３は、第２実施例の反射屈折光学系の構成図である。

【図４】図４は、第２実施例の反射屈折光学系の収差図である。

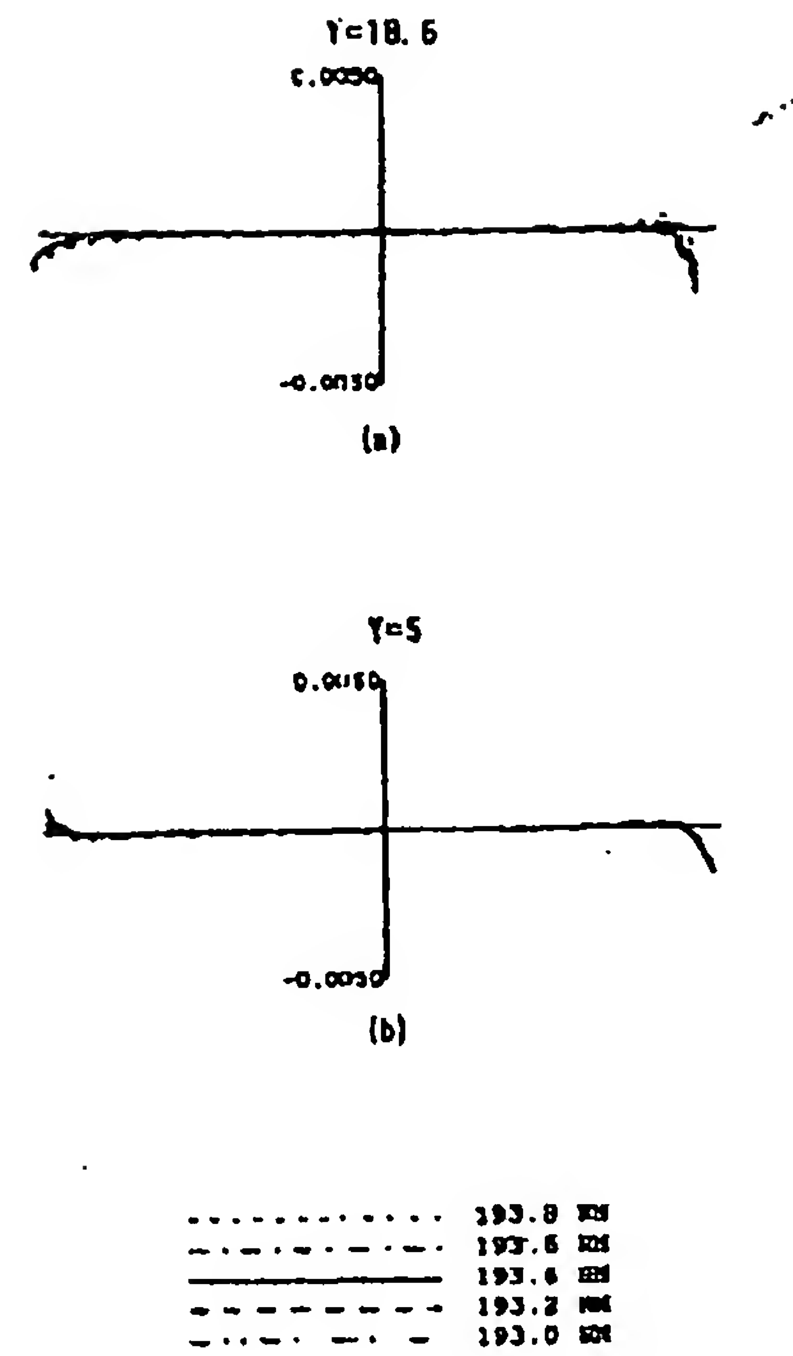
【符号の説明】

Ｓ１	第１結像光学系
Ｓ２	第２結像光学系
Ｇ１	第１レンズ群
Ｇ２	第２レンズ群
Ｍ１	凹面鏡
Ｍ２	第１光路偏向部材
Ｍ３	第２光路偏向部材
ＡＳ	非球面に形成された面
ＡＰ	開口絞り
Ｒ	レチクル
Ｗ	ウェハー

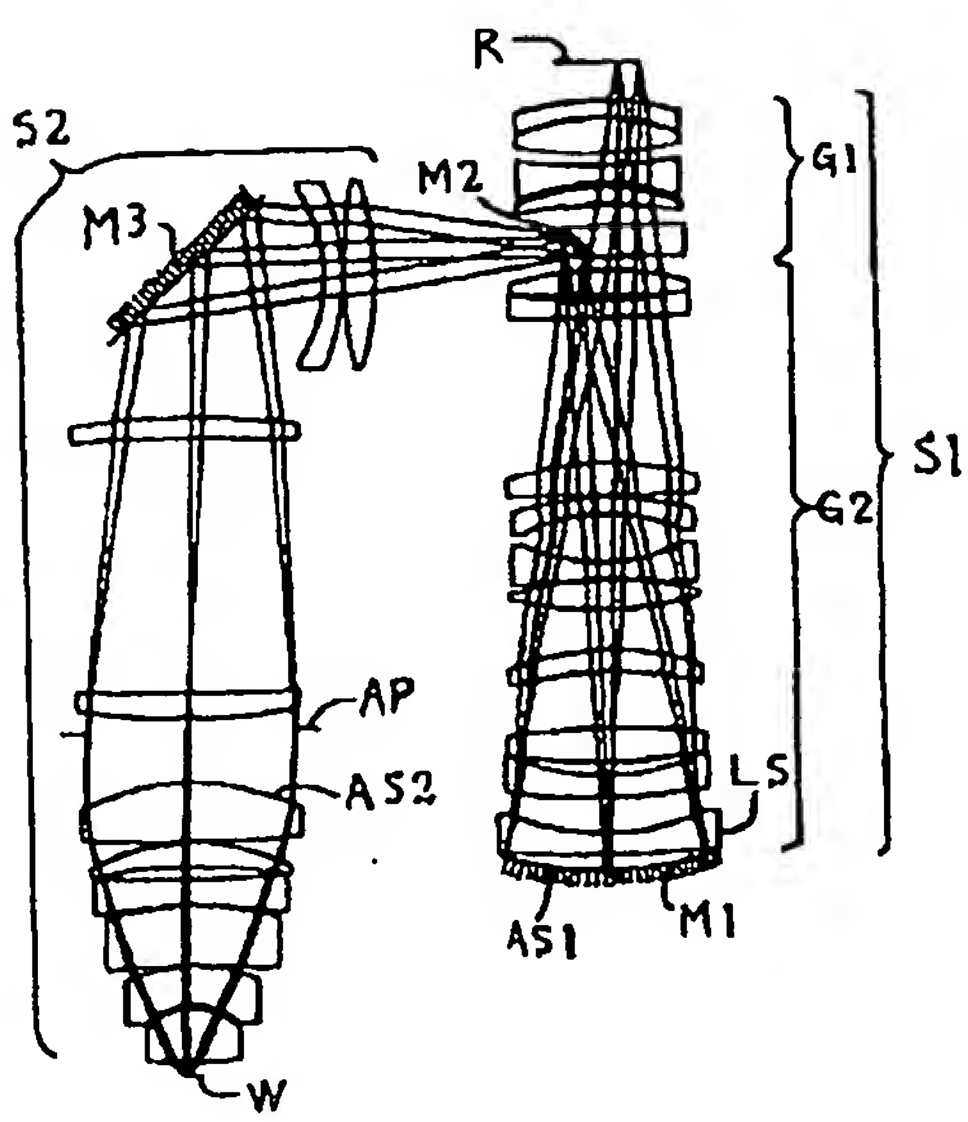
【図1】


R
S2
M2
M3
G1
G2
S1
AP
AS1
AS3
LS
AS2
M1
W

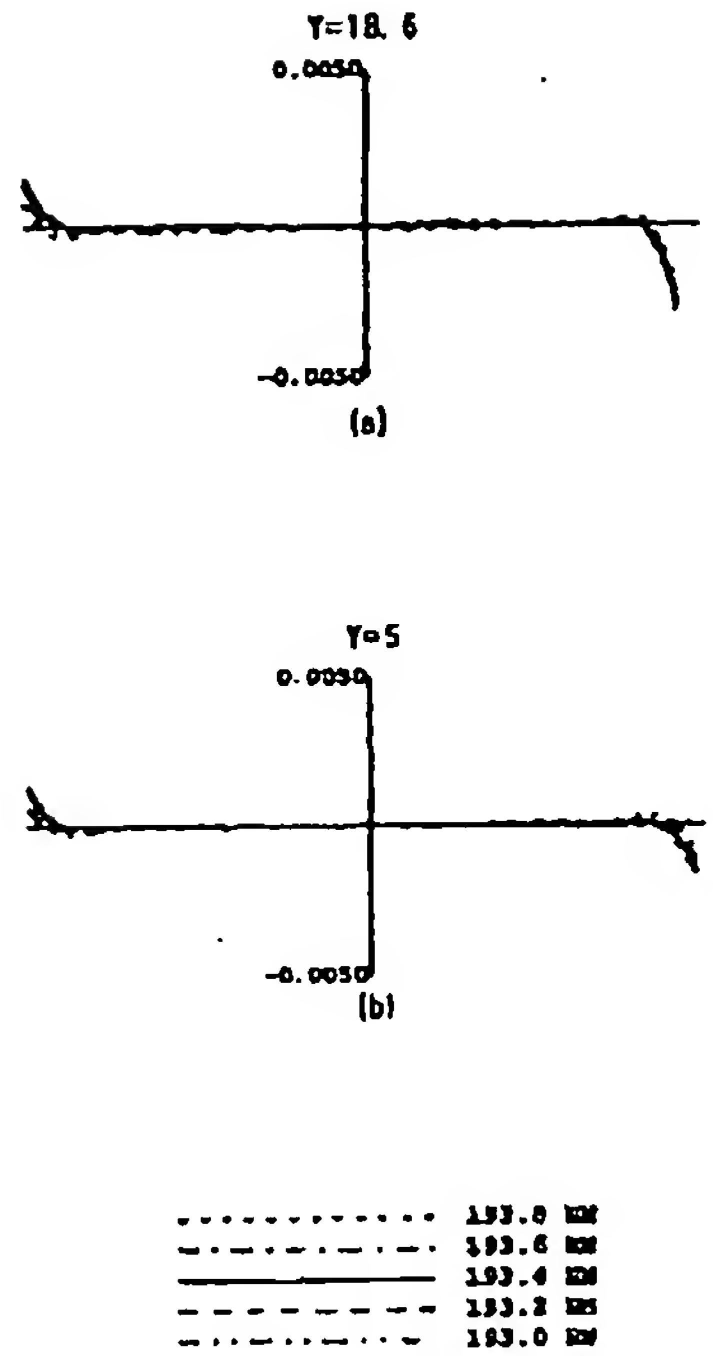
【図2】


Y=18.6
0.0050
-0.0050
(a)
Y=5
0.0050
-0.0050
(b)
193.8
193.6
193.4
193.2
193.0

【図3】


R
S2
M2
M3
G1
G2
S1
AP
AS2
LS
AS1
M1
W

【図4】



フロントページの続き

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			H01L 21/30	517	

【公報種別】特許法第１７条の２の規定による補正の掲載
【部門区分】第６部門第２区分
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Ｇ０２Ｂ　17/08
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Ｇ０３Ｆ　7/20
Ｈ０１Ｌ　21/027
【ＦＩ】
Ｇ０２Ｂ　17/08　　　Ａ
Ｇ０２Ｂ　13/18
Ｇ０２Ｆ　1/13　１０１
Ｇ０３Ｆ　7/20　５２１
Ｈ０１Ｌ　21/30　５１５Ｄ
Ｈ０１Ｌ　21/30　５１７

【手続補正書】
【提出日】平成15年10月28日(2003.10.28)
【手続補正１】
【補正対象書類名】明細書
【補正対象項目名】発明の名称
【補正方法】変更
【補正の内容】
【発明の名称】反射屈折光学系、投影露光装置及び投影露光方法
【手続補正２】
【補正対象書類名】明細書
【補正対象項目名】特許請求の範囲
【補正方法】変更
【補正の内容】
【特許請求の範囲】
【請求項１】
光線が進行する順に、屈折部材によって構成された第１結像光学系と、凹面鏡と、屈折部材によって構成された第２結像光学系とを含み、半導体素子のパターンを基板上へ投影する反射屈折光学系において、
前記第１結像光学系を構成する屈折部材及び前記第２結像光学系を構成する屈折部材のうち、少なくとも１つの屈折部材は非球面を有することを特徴とする反射屈折光学系。
【請求項２】
前記第１結像光学系は、光線が一度だけ通過する第１レンズ群と、光線が往復する第２レンズ群とからなり、
該第２レンズ群の最も凹面鏡に近いレンズは、負レンズであり、
前記第２レンズ群を射出した光線は、前記第２結像光学系に入射する前に前記半導体素子のパターンを一度結像することを特徴とする請求項１記載の反射屈折光学系。
【請求項３】
前記第１結像光学系と前記第２結像光学系との間に光路偏向部材を配置したことを特徴とする請求項１又は２記載の反射屈折光学系。

【請求項４】
前記第１結像光学系を構成する屈折部材及び前記第２結像光学系を構成する屈折部材は、石英及び蛍石、またはその何れか１つの硝材により構成されることを特徴とする請求項１乃至３の何れか一項記載の反射屈折光学系。
【請求項５】
前記凹面鏡は非球面形状であることを特徴とする請求項１乃至４の何れか一項記載の反射屈折光学系。
【請求項６】
レチクルのパターン像を基板上に露光する反射屈折光学系において、
屈折部材と凹面鏡とを有する第１結像光学系と、
前記第１結像光学系と前記基板との間の光路中に配置されて、屈折部材を有する第２結像光学系とを備え、
前記第１及び第２結像光学系を構成する屈折部材のうち、少なくとも１つの屈折部材は非球面を有することを特徴とする反射屈折光学系。
【請求項７】
前記第１結像光学系は、前記レチクルと前記凹面鏡との間の光路中に配置された第１レンズ群と、該第１レンズ群と前記凹面鏡との間の光路中に配置された第２レンズ群とを備え、
前記第１レンズ群には光線が一度だけ通過し、かつ前記第２レンズ群には光線が往復通過し、
前記第２レンズ群は、最も前記凹面鏡に近接配置される負レンズを備え、
前記第１結像光学系と前記第２結像光学系との間の光路中には前記レチクルの中間像が形成されることを特徴とする請求項６記載の反射屈折光学系。
【請求項８】
前記第２レンズ群は、少なくとも２つの異なる負屈折力を持つ屈折部材と、少なくとも２つの異なる正屈折力を持つ屈折部材とを備えていることを特徴とする請求項７記載の反射屈折光学系。
【請求項９】
前記第１レンズ群は、少なくとも３つの異なる屈折力を持つ屈折部材を備えていることを特徴とする請求項８記載の反射屈折光学系。
【請求項１０】
前記第１レンズ群中の前記少なくとも３つの異なる屈折力を持つ屈折部材は、調整用のレンズを備えていることを特徴とする請求項９記載の反射屈折光学系。
【請求項１１】
前記第１結像光学系と前記第２結像光学系との間の光路中に配置された光路偏向部材をさらに備えていることを特徴とする請求項６乃至１０の何れか一項記載の反射屈折光学系。
【請求項１２】
前記第１及び第２結像光学系を構成する屈折部材は、石英及び蛍石、またはその何れか１つの材料により構成されることを特徴とする請求項６乃至１１の何れか一項記載の反射屈折光学系。
【請求項１３】
前記凹面鏡は非球面形状を有することを特徴とする請求項６乃至１２の何れか一項記載の反射屈折光学系。
【請求項１４】
前記第２結像光学系は、可変絞りを備えていることを特徴とする請求項６乃至１３の何れか一項記載の反射屈折光学系。
【請求項１５】
投影光学系を介してレチクルの像を基板上に露光する投影露光装置において、
前記レチクルの像を前記基板上に転写するための請求項１乃至１４の何れか一項記載の

反射屈折光学系を備えていることを特徴とする投影露光装置。
【請求項１６】
　投影光学系を介してレチクルの像を基板上に露光する投影露光方法において、
　請求項１乃至１４の何れか一項記載の反射屈折光学系を用いて前記レチクルの像を基板上に転写することを特徴とする投影露光方法。
【手続補正３】
【補正対象書類名】明細書
【補正対象項目名】０００１
【補正方法】変更
【補正の内容】
【０００１】
【発明の属する技術分野】
本発明は、例えば半導体素子、または液晶表示素子等をフォトリソグラフィ工程で製造する際に使用される投影露光装置で用いられる光学系、特に、光学系の要素として反射鏡を用いることにより、紫外線波長域でクオーターミクロン単位の解像度を有する反射屈折光学系、該反射屈折光学系を用いた投影露光装置及び該反射屈折光学系を用いた投影露光方法に関する。
【手続補正４】
【補正対象書類名】明細書
【補正対象項目名】０００７
【補正方法】変更
【補正の内容】
【０００７】
本発明は斯かる点に鑑み、紫外線波長域で大きな開口数を達成し、光学系全体が実用的な大きさで、クオーターミクロン単位の解像度を有し、光学系の各構成部材を小型化した反射屈折光学系、該反射屈折光学系を用いた投影露光装置及び該反射屈折光学系を用いた投影露光方法を提供することを目的とする。
【手続補正５】
【補正対象書類名】明細書
【補正対象項目名】００２１
【補正方法】変更
【補正の内容】
【００２１】
【発明の効果】
以上のように、本発明では、紫外線波長域で大きな開口数を達成し、光学系全体が実用的な大きさで、クオーターミクロン単位の解像度を有し、更に製造も容易な反射屈折光学系、該反射屈折光学系を用いた投影露光装置及び該反射屈折光学系を用いた投影露光方法を提供することが可能となった。